Chapter 7
Investigating the Factors, Challenges, and Role of Stakeholders in Implementing Industry 5.0 and Its Impact on Supply Chain Operations: A Study of the Global Agri-Food Supply Chain

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ABSTRACT

Industry 5.0 may assist businesses to become more constructive and competitive in the global economy in the Fifth Industrial Revolution era. Therefore, a critical review of prior literature is presented in this paper to examine how industry 5.0 will impact supply chain operations within the agricultural sector. Additionally, it examines influencing factors, challenges, stakeholder roles, and recommendations identified from the literature. Industry 5.0 has multiple benefits for the agri-food sector such as improved agility, responsiveness, efficiency, productivity, precise decision-making, as well as cost-effectiveness.

INTRODUCTION

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Industry 5.0 is a process of twining the twins of 'the green' and 'the digital transitions', to build a more efficient, sustainable and resilient society and economies (European Commission, 2021). The Covid 19 has further exposed the negatives of too much reliance on efficiency, innovation, technology and productivity and has made people think about sustainability, inclusivity, employability, humanistic approach, building more resilient supply chains and adopting more sustainable ways of production and balancing the needs of various flora nd faunas of the planet earth (European Commission, 2021). The emergence of digitalization and digital technologies in various sectors today has revolutionized industries in ways that have led to improved operational performance and the integration of the entire supply chain throughout. A constant fluctuation in supply demand, disruptions, or natural disasters as well as insufficient visibility to balance the supply chain has elevated the difficulties for an unstable supply chain. Integrating emergent digital technologies may contribute to creating new opportunities, principles, and a few challenges in supply chain management (Azzi et al., 2019, Oliveira-Dias et al., 2022). The emerging digital technologies have revolutionised the Industry to 4th Industrial revolution ie "Industry 4.0", thus accelerating operational performance, and leading to producing new strategies or opportunities with highly customized systems. Using Industry 4.0 technology, manufacturers can become more cost-effective, provide high-speed production with agility and flexibility, and enhance quality. (Jagtap et al.,, 2021),. Industry 4.0 is the convergence of smart manufacturing and products, and the internet of things (IoT), which provides real-time data about the production, machines, and component flow (Chauhan and Singh, 2019). As digital technologies have advanced over the last decade, industries have gained significant control over products and processes via IoT, artificial intelligence, big data analytics, 3D printing, augmented reality, and machine learning (Sahoo and Lo, 2022).

According to Hassoun et al., (2022), it is becoming more prevalent in various sectors, including the food industry, to witness the fourth industrial revolution. In addition, it is becoming increasingly important for the agri-food supply chain to make use of advanced digital technologies and to evolve into an intelligent, autonomous, and data-driven system of systems (Lezoche et al., 2020). According to the world bank report, several technologies have been observed to be promising for addressing existing constraints in the agri-food system, such as remote sensing, blockchain and IoT (The world bank, 2021). As digital technologies are introduced into diverse food systems, capturing, storing, processing, and communicating information are integrated digitally (Donaldson, 2021). Adopting digital technologies in the food industry allows one to identify ongoing and future trends and understand the consumer's intake based on nutrients, food quality, taste experiences, etc. (Chapman et al., 2021). As a result, it is critical to maintain high-quality products and to adhere to regulations strictly, and digital technologies can contribute to ensuring the standardized product to consumers. The Global Digital Agriculture Market was valued at USD 12.8 billion in 2021 and is expected to reach a value of USD 22.1 billion by the year 2028 (Vantage Market, 2021). In addition, Market analysts predict that the global market will grow at a compound annual growth rate (CAGR) of 9.6%.

A real-time information system allows both the production system and consumers to gain access to information about the entire production process, thus facilitating efficient, transparent, and cost-effective food supply chain operations (Ada et al., 2021). The rapid aging of the population combined with diseases (e.g., diabetes, obesity) has dramatically impacted consumer food choices and therefore, several challenges are appearing in the industry, including food security, fraud, and waste (Chapman et al., 2021). Also, the challenges occurring in the agri-food sector mostly are related to weather sensitivity, market disruptions, low efficiency and effectiveness, and external barriers such as poor stakeholder linkages (Lezoche et al., 2020). To overcome the challenges, Yadav et al., (2022) argue for leveraging industry

4.0 technologies, an industry such as agri-food can become smarter, integrated, agile, autonomous, and connected by being more intelligent, smart, and smart. However, the adoption of new technologies in the food industry is slower than that in other sectors due to the complexity of the process (Hassoun et al., 2022), lack of understanding of the deployment of the digitalized supply chain (Büyüközkan and Göçer, 2018) and due to limited understanding of the key role of specific technologies in operations and the supply chain in manufacturing industries (Oliveira-Dias et al., 2022).

According to the PricewaterhouseCoopers 2018 report, digital maturity varies across the globe. The Asian Pacific region appears to have the most advanced companies, with 19% of companies in the Digital Champion category,, 33% in the digital innovators' category and the rest being followers and Novice. In the Americas, 11% of companies in the Digital Champion category, 39% in the digital innovators' category and the rest are followers and Novice . in European markets (EMEA), only 5% of companies in the Digital Champion category, 20% in the digital innovators' category and the rest are followers and Novice (Geissbauer et al., 2018).

Lezoche et al., (2020) argue that soon, all agricultural processes will be fully integrated into the food chain through semantically active technologies. It means that each process involved in the agri-food supply chain subsequently will be digitized to maintain an efficient and effective supply chain. A report published by the Food and Agriculture Organization of the United Nations has analyzed the readiness of industry 4.0 technologies in the agri-food sector as measured by the level of maturity (FAO, 2022). The report found that in certain fields of agriculture such as, livestock Automation, whole farm digitalization of crops, protected crop farming, tractors & machinery production, etc the Agriculture market is almost reaching the maturity stage of Industry 4.0 and is smart devices, using AI, robotics and Data analytics etc; however in fields like full crop automation, Aquaculture automation the industry is still at nascent prototype site (FAO, 2022). Agriculture as an economic sector also referred to as the "farm-to-fork supply chain", "Plough to Plate supply chain", or "Agri/agro-food supply chain plays a crucial role in economic development, environmental sustainability, and social well-being (Yadav et al., 2022), Almost 44 million jobs in food processing, food retailing, and catering are supported by agriculture, which currently employs 12 million farmers (FAO, 2020). In addition, it is observed that there is a remarkable share of the food industry in the UK economy, and it contributes £28.2 billion (17% of the total manufacturing global value added) to the economy annually (Jagtap et al., 2021). However, the agri-food industries are currently facing a few challenges at each stage of the supply chain such as labour shortages, increasing costs, delayed lead time, food waste, food quality, safety, etc. Currently, the organizations are working to resolve the issues by considering all the aspects of the supply chain and improving the sustainable supply chain performance by marrying the digital technologies with Environmentally friendly Green approaches to maintain the supply chain integrity.

However, an agriculture industrial practice predominately dominated by digital technology and ignoring the needs and impacts on humans, society, the environment and sustainability will be not only unethical, and illegal but also can be disastrous to mankind. While Industry 4.0 is flourishing, we need to get ready for the fifth industrial revolution ie Industry 5.0. Industry 4.0 is more about machine lead efficiencies, cost savings, automation etc, industry 5.0 will be about containing the negative consequences of industry 4.0 on various stakeholders and balancing the scorecard on the metrics of sustainability, and contributions to human, social, and environmental and governance, ESG (environment, social, and governance), and a shift from one P – productivity – to three Ps, namely productivity, people, and the planet. There are many mandatory requirements such as United Nations Sustainable Development Goals (SDGs), Good Manufacturing Practices (GMP), International Organization of Standardization (ISO),

American Society for Testing and Materials (ASTM), corporate social responsibility (CSR), Environment, health and safety (EHS). Philanthropy and Sustainability practices are leading organizations and stakeholders to think about Industry 5.0 as a way forward (Heartland, 2022).

The primary aim of researching and developing this chapter is is to Investigate the impact of Industry 5.0 on supply chain operations within the context of the global agri-food supply chain. The chapter will explore existing literature on industry 4.0 and Industry 5.0 on supply chain operations and analyse the related factors, challenges, and key stakeholders.

LITERATURE REVIEW

The section examines how digital technologies are intertwining with human-centric, Green and sustainability approaches and aiding the agri-food supply chain and aiding in a more efficient, effective, agile, innovative, sustainable Supply chain

Operations management includes the planning, scheduling, and managing of the activities to transform the input into products or services based on technical, organizational, and environmental perspectives. The operations function in broader Supply Chain Management (SCM) includes 'the collection of people, technology, and systems within an organization with primary responsibility for providing the organization's products or services (Bozarth and Handfield, 2019, p.23). Supply chain management covers the whole process of designing and delivering products to consumers at the right time, cost, quality and flexibility. The SCM activities, requires significant structural changes and significant investments based on the organization's strategy and performance objectives. Operational decisions have a strategic dimension, driving the overall strategy that governs the direction of the operation and impacts all other decisions. Planning and controlling all supply chain activities are necessary to ensure the effectiveness of this process. The process from manufacturer to consumer is always interlinked with the physical, informational, and financial flow. The various functional areas such as purchasing, manufacturing, and sales and distribution ought to be integrated using Information and Communications Technologies (ICTs) to minimize materials costs in purchasing, reduce production costs in manufacturing, increase sales volume, and lower warehouse and inventory costs in distribution(Jacobs and Chase, 2020).

In operations management, to drive towards excellence, an organization must ensure total quality management (TQM), continuous improvement including their suppliers and buyers and improving effectiveness and responsiveness (Radnor and Barnes, 2007). Nowadays, using ICT and digital technologies it is becoming easier to track all the records of the product in the system, even the date, time and username are recorded in the software. To manage information flow within supply chains, centralized management systems are commonly used, such as enterprise resource planning (ERP) systems to move from manual work in SCM to fully automated operations and systems (Hossein Ronaghi, 2020). The management of operations has eveloved from Manafucationg strategy development (the 1960s) t0 Just in time and Kanban systems (1970s), Total quality management & Service quality Productivity (1980s), Six sigma (1990s), Business Process Reengineering & Supply chain Management (1990s), E-commerce & sustainable SCM (2000s), to Industry 4.0- Business analytics, AI, Internet of Things, Automation (2010) to Industry 5.0 (2020s) (Jacobs and Chase, 2020).

Supply-Chain Operations Reference model or SCOR model evaluation framework integrates process re-engineering, benchmarking, and measurement in SCM, and thus allows organizations to have a modern management approach that improves customer satisfaction, increases delivery flexibility, increases

product reliability and reduces costs (Sundarakani et al., 2018). The SCOR model involves using ICT for integrating, balancing and coordinating the five repetitive processes such as plan, make, source, deliver, and return of resources and information from suppliers of supplers and customers of customers in both directions (NC State University, 2004). Indeed, digital supply chain involves ERP, RFID, customer relationship management (CRM), collaborative planning forecasting and replenishment, and e-procurement systems(Ageron et al., 2020), emerging technologies such as Artificial intelligence (AI), Blockchain technologies offer more than RFID and ERP to the operations supply chain management discipline, such as intelligent contracts for automating processes and good P2P verification. Therefore, implementation of industry 5.0 is necessary to include and integrate the emergent technologies as well as the interoperability process across them.

INTRODUCTION OF SUPPLY CHAIN REVOLUTION

The industrial revolution concept was first presented during the Hannover Fair in 2011 and was subsequently announced in 2013 as a German strategic initiative intended to take a leading role in industries that are currently revolutionizing manufacturing (Xu et al., 2018). A new paradigm of manufacturing, processing, distributing, packaging, retailing, and transporting products has emerged with Industry 4.0. Nowadays, the Industry 5.0 approach involving the integration of digital supply chains into traditional supply chains along with Environmental, Social, Governance (ESG) and sustainability with a humanistic approach has become crucial for improving value chains, responsiveness, integrity and reliability towards various stakeholders (Aamer et al., 2022). Using the Industry 4.0 approach to manufacturing causes difficulties of coping with a variety of challenges, including economic, environmental, sustainability and technological challenges (Mohamed, 2019). By leveraging the technology and information systems, along with green & sustainable practices, it is becoming easier to integrate suppliers, manufacturers, and consumers, eliminating poor performance from suppliers and erratic customer demands in real-time (Joubert and Jokonya, 2021). Thus where on one hand adopting digital technologies it is possible now for organizations or industries to manage the supply chain effectively and efficiently by reducing lead time, cost, and manual efforts with an increasing amount of accuracy and profit and on the other hand by integration with sustainability, green environmental and humanist approaches, the supply can better meet the needs of various stakeholders. To transform the traditional supply chain approach to a digital supply chain, the significance of digitalization is proliferated since the industrial revolution. Streamlining the supply chain with a digital supply chain ensures real-time information sharing and improved communication using Industry 4.0 paradigm (Xu et al., 2018). However, to create value for products or services in the global market, maintaining the informational, financial and data flow with trust, transparency and communication and sustainability, we need Industry 5.0 paradigm. Such a humanistic, sustainable and digital supply chain is termed as Supply chain management 5.0 and entails Emerging technologies such as Artificial Intelligence (AI)M, Robotics, Machine learning (ML), Augmenter Realty (AR), blockchain technology, big data analytics (BDA), cloud computing, additive manufacturing, Cyber security systems, 3-D technologies, machine-to-machine communication, and cyber-physical systems (CPS)Big data, Internet of Things (IoT) (Parhi et al., 2022) along with human -social- enviro centric sustainable approach to revolutionize production, design, planning, logistics, distribution, and consumption.

The new production technologies, such as Industry 4.0 or the IoT, enable organizations to offset labour cost advantages associated with offshoring and move production back to increase flexibility and

diminish lead times and suataiblity practices making use of technology more humanistic (Industry 5.0). It is also noteworthy that in the United States, approximately 66 percent of firms use advanced digital technologies while in the European Union, 61 per cent do so (EIBIS, 2022).

Among the digital technologies emerging under Industry 4.0 is Blockchain, which has many applications across a variety of sectors including the agri-food sector (Hassoun et al., 2022). To illustrate, incorporating blockchain technology into food safety, monitoring, and traceability measures is a priority for Walmart, a retail giant (Agarwal et al., 2022). Similarly, technologies such as Radio Frequency Identification (RFID), robotics, automation, additive manufacturing, 3D Printing, etc. can contribute to enhancing operations in industries with accuracy and reduces man-made defects. According to the Deloitte (2022) survey, the Industrial Internet of Things (IIoT) at which machines are connected and processes are automated is expected to further increase operational efficiency by 45% in manufacturing. Furthermore, IoT plays a crucial role in offering an extensive range of opportunities such as monitoring the location and speed of vehicles remotely and real-time surveilling of the condition of perishable products through temperature sensors, status, and performance of machines, etc. (Manavalan and Jayakrishna, 2019).

Industry 4.0-based integrated supply chains and highly integrated digital platforms increase cost efficiency, reduce labour requirements and errors along the supply chain, and increase market responsiveness and overall competitiveness (Kittipanya-Ngam & Tan, 2019).

However, despite the benefits of digital transformation, most companies are reluctant to initiate the process to Industry 5.0 because of significant implementation barriers such as inadequate knowledge & awareness, and uncertainty about various benefits (Mohamed, 2019). Though there are many challenges associated with multiple factors, several global retailers, including Amazon and Alibaba, use drones and robotic automation for delivering goods as well as handling goods (Büyüközkan & Göçer, 2018). In the agri-food sector, the farmers are reluctant to adopt modern technologies and from detaching the past. The implementation of Industry 4.0 itself poses many technological challenges, with significant impacts on many dimensions of today's manufacturing industry (Pereira et al., 2017), so going for Industry 5.0 is quite a far and difficult path for industries,

APPLICATION OF INDUSTRY 5.0 TECHNOLOGIES ON OPERATIONS

Increasing efficiency and productivity while not removing human workers from the manufacturing industry and producing sustainable products and services is imposing many challenges on the global SCM. Industry 5.0, expects robots to be intertwined with the human brain and work as a collaborator instead of competitors (Nahavandi, 2019). The operations in supply chain management involve complex and interconnected decision-making processes in supply chain management, integrating digital technologies can improve their efficiency, flexibility, agility, robustness, ability to withstand uncertainties and sustainability, (Rodríguez et al., 2020). Thus the supply chain needs to be integrated vertically and horizontally, optimised across a wider network, and adjusted to market changes by enabling autonomous operations using digital manufacturing thus leading to more customer satisfaction, product quality, and performance, reducing costs, variety, or flexibility, service level and human resources (Zhou et al., 2021) The Industry 4.0 is an era of highly autonomous intelligent systems in industrial production processes involving implementation of cutting-edge technology, such as robotics and smart sensors throughout the supply chain (Hassoun et al., 2022),. Industry 4.0 has lead to organizational re-designs, operations management developments, market transformations, and organizational transformations (Ivanov et al.,

2020). Industry 4.0 has creted 'smart factories' which can visualse and simulate operations with the integration of advanced design software and production systems (Rashid and Tjahjono, 2016). The performance of operations and processes can be influenced in in terms of quality, speed, dependability, flexibility, and cost; all of which will have a significant impact on the satisfaction of customers and the competitiveness of businesses (Slack & Brandon-Jones 2022).

Due to digitalization in global supply chains, there is an increasing realisation that the optimisation of global supply chains without considering human externalities provides only a partial and misleading view of the impacts of technologies (Mithas et al., 2022). Hence there is a stronger need of integration of industry 4.0 technologies with ESG approaches in the agri-food supply chain. Initially in the production and processing stage, the adoption of digital technologies can lead to improving the operational performance as well as the quality evaluation of food and the suppliers. However, the long terms benefits of society lies in sustainable production practices, precision agriculture, and the quality assessment of raw materials suppliers are supported by technologies used at the production and processing stage ie in Industry 5.0 (Yadav et al., 2022)

One of the emerging technologies, big data analytics can contribute to the decision-making in agri-food supply by estimating consumer preferences and expectations to a higher standard, designing, and developing the products based on real-time market demands, and improving the overall business performance (Rejeb et al., 2021). Also in the logistics or transportation stage, organizations can adopt digital technologies along with sustainable practices to reduce carbon emissions, and food waste, and improve the real-time monitoring of the food while shipping, and information sharing. An IoT system uses a range of technogies such as RFID, Wireless Sensor Networks (WSN), Near Field Communication (NFC) technology, AI, ML, Big data ananlytics, etc., to collect, store and analyze the data in all the stages of the supply chain (Feng et al., 2020). The drones can be used to spray pesticides and or to deliver products as well. RFID tags can be used in retailing, and logistics to maintain and control an inventory and reduce waste. The ICT technology enables effective agro-e-commerce and trading at the consumption stage enables provenance tracking and promotes circular economy initiatives (Yadav et al., 2022).

Any technology can have multiple benefits in various stages of SCMs. Through Agriculture 4.0, and 5.0, sustainable and digitalised ways of farming have the potential to generate renewed interest in digitising traditional practices and operations, focusing on analytics and decision-making (Spanaki et al., 2021). However, because of the lack of information sharing among various actors involved in the SCM, there can be issues related to unbalanced supply & demand, price volatility, and food scarcity, all of which in turn can adversely impacts logistics efficiency, cost containment, risk management, customer intimacy, consumer confidence, and sustainability (Liu et al., 2021).

There are several factors such as market demand, governance, employee skill sets, and costs that may affect the digitalization of operations and supply chains (Juhani 2022). The extreme weather events, biodiversity loss, and the need to make soil healthier, farmers requiring increased innovation etc require the implementation of Industry 5.0. For example, Syngenta has collaborated with Insilico Medicine, to create and design crop protection products as well as products that protect the soil, allowing it to retain carbon, which reduces greenhouse gas emissions from agriculture by using AI (Syngenta, 2021). Also, the COVID-19 restriction on travel has led Nestlé to expand its use of augmented reality technology to provide virtual support to production, research and development sites and suppliers which results in increased efficiency throughout the operations (Nestle, 2020).

INDUSTRY 5.0 IN AGRI-FOOD SUPPLY CHAIN AND OPERATIONS MANAGEMENT

As many researchers have found that digitalisation has revolutionized multiple industries including agri-food industry. In the era of Industry 4.0, and industry 5.0, the knowledge and technology spanning physical, digital, and biological domains are integrated with green and human centric approaches ((Echegaray et al., 2022). The traditional agri-food industry heavily relied on manual work handling with equipment whereas agri-food 5.0 is majorly dependent on automation along with sustainability practices, which enables the industry to maintain transparency, productivity, profit, and sustainability across the globe (Liu et al., (2021),

Like the Industrial revolution 1.0 to 5.0, the Agricultural sector has also moved from Agri-food 1.0 to Agre-food 5.0, though at a time-lagged phase. The Agri-food 1.0 involved heavy labour work including the use of manual workers, animals for agricultural production etc. Agri-food 2.0 replaced manual work, animals with machinery such as steam engines, and tractors et so as improve productivity and reduce labour work. The Agri-food 3.0 used monitoring, bio-medical technologies, tested managers and electronic systems for more effective agriculture. Agri-food 4.0 uses ICT & IoT to automate the processes and the real-time data analysis and tracking of the food during the entire supply chain thus increasing productivity by 25% through automation (Aday & Aday, 2020). Industry 5.0 would embed Industry 4.0 with human, social, environmental and sustainable approaches to achieve a sustainable and smart farming system.

However, Industry 4.0-based agri-food supply chains could have concerns such as food fraud, increased cost of the final product, transparency, traceability, sustainability and limits in achieving UNOs Milleneam Development Goals (MDGs) (Dadi et al., 2021), In the past few years, the customer's confidence in agri-food supply chain has been undermined by a variety of food incidents, the horsemeat scandal in Europe, salmonella outbreaks in the USA, genetically modified foods, and mad cow diseases among others (Yadav et al., 2022).

Therefore, the need to use Agri 5.0 to embed suitable approaches, increase awareness of food safety and quality and implement digital technology to reduce manual errors, ensuring full employment. Food fraud including mislabelling the product, cheap quality ingredients or products, adulteration of food, etc. is not only affecting business but also serious impact on the consumer's health. Also, food traceability, food waste, green food, and high carbon footprints in the food supply chain require innovative approaches of embedding Blockchain technologies, IoT, and AI along with sustainability and ESG practices in Agriculture, and thus going for Industry 5.0.

Blockchain technology can aid in maintaining transactional data, tracing tags, and clarifying contract terms between farmers, landowners, manufacturers, and vendors (Hossein, 2020). With the use of robotics and automation, a product can be made more effective and accurate with fewer defects, whilst increasing productivity and reducing costs. Similarly, to customize food design, nutrition, and composition, 3D food printing offers new and innovative manufacturing technologies (Zhang et al., 2021). Digital technologies have been successfully applied in the agri-food industry in a variety of ways, but investment decisions must be studied, such as whether the technology should be applied in agri-food supply chain and at what point it should be integrated into the existing system (Yadav et al., 2022).

As industry 5.0 approach will not only enhance the efficiency of the agri-food supply chain by eliminating unnecessary waste, reducing outbreak costs, product recalls, and cross-contamination risks but also make production more sustainable and humanistic (Yadav et al., 2022). Industry 5.0 technologies

can assist with mitigating the challenges involved in the agri-food supply chain pre and post-harvesting mitigating risks of wastage, losses, and high costs and promoting sustainability through information sharing and collaboration between suppliers and buyers. The IoT platforms along with the ESG approach can enhance agricultural data collection by providing additional data sources, providing a broader range of information about water, soil, humans, animals, environment, social and Governance etc (Spanaki et al., 2021).

RESEARCH METHODOLOGY

This chapter has been researched, developed and synthesised by conducting a Systematic Literature Review (SLR). The SLR ensures comprehensive coverage of the literature for future searches and ensures a comparable result. According to Kitchenham et al., (2009, p.8), SLR aggregates all existing evidence on a research question to support the development of shreds of evidence. The scope of the research used themes such as, Industry 4.0 Industry 5.0, Supply chain Management and, agriculture and Operation. The databases such as Scopus, PubMed, ScienceDirect and Google Scholar were considered to collect different types of articles, journals, and grey literature to support the evidence in the literature. Following the first screening step, the secondary screening step involved the review of the full text of the documents with the specified keywords.

Findings and Results on Digitalisation and Industry 4. In SCM

The articles published between periods 2011 and 2022 were reviewed. It can be observed that the agri-food supply chain lagged for around three years (The year 2014) in the use of advanced technologies as compared to Industry 4.0 (the year 2011 due to resistance from farmers or organizations. From 2014 to 2019, an almost 6-fold rise in papers related to Agri-food 4.0 Almost 89% of the research work has been based on whole supply chain management and lesser on operations management (9%.). Out of 61 research papers shortlisted, 42 were qualitative and the majority of researchers had used the SLR approach (23) and conceptual approaches (17) and very few were empirical (9) conference papers (4) industrial reports (2) or other kinds of Research methods (4). The majority of research papers were on agri-food (34%) and food processing (34%) and other articles were referred from other industries such as the manufacturing industry (24%) and others, To assess the impact of industry 4.0 or Industry 5.0 technologies on supply chain operations.

THEMATIC ANALYSIS OF DIGITALISATION OF AGRI SCM

A two-by-three typology matrix (3- levels of management decisions eg Strategy, Tactical, Operational, and crosstab with internal and external elements) has been used to identify the factors, challenges, stakeholder roles, and recommendations related to managing the implementation of Industry 5.0 and the impact of industry 5.0 on supply chain operations

Factors Influencing the Implementation of Industry 5.0

Several internal and external factors such as employee skill development, technological infrastructure, political support, and software capabilities are necessary for the effective implementation of Industry 5.0 (Parhi et al., 2022). The next section discusses the main factors driving Industry 5.0 and its influence.

Lack Of Strategic Roadmap

The successful implementation of Industry 5.0' requires appropriate and clear strategic guidelines (Kumar et al., 2021). The research found this theme that the organizations lack a defined strategy, vision, and roadmap for executing Industry 5.0 into practice (Kumar et al., 2021; Osterrieder et al., 2020). To build a strategic roadmap the readiness of the top management and organizations are crucial.. It has been found that agri-food producers lack the adoption of differentiation strategies and thus resulting in lower digital maturity. The integration of industry 5.0 into the organisational strategy is an important success factor for the change process (Mayer et al., 2017). A lack of a strategic roadmap to implement industry 5.0 can pose multiple challenges to organizations, such as misunderstanding the role and effectiveness of technologies, mismatching market requirements, and paralyzing forecasting capabilities (Aday & Aday, 2020). it is also found that around a small percent of technology suppliers or manufacturers have an overall Industry 4.0 or Industry 5.0 strategy (USA 27%, Germany 20%, Japan 17%) in place, slightly high percentages have clear responsibilities (USA 30%, Germany 31%, Japan 10%) and meager percent (USA 20%, Germany 19%, Japan 15%) have assigned clear roadmap for implementations of for Industry 4.0 or 5.0 (McKinsey Digital, 2016).

Lack of Government Support

To implement industry 5.0 technologies in organizations, the role of government t & politics to support the organizations directly or indirectly is very crucial (Hoyer et al., 2020). The mid-2014 despite of the risks, pioneers that implemented smart factory systems with government support demonstrated the ability to implement an emerging technology rapidly for a strategic business opportunity (Choi & Choi, 2018). For an instant, India's Department of Heavy Industry (DHI) launched Udyog Bharat 4.0 as part of its Industry 4.0 initiative for strengthening competitiveness (Majumdar et al., 2020). However, besides facilitating funding-related issues, governments can also support remote industries by extending broadband Internet access, and marketing Zhao et al., (2022), found that the Argentinian government has a significant role in supporting general agricultural services such as research and development, training, marketing, and public stockholding. The Government and political institutions can help Industry 5.0 through financial aid, R&D budgets, infrastructure and education support, and reducing taxes (Hoyer et al., 2020). According to Eurostat statistics total government R&D budget allocations across the EU in 2021 were €109 250 million, which is equivalent to 0.75% of GDP (Eurostat, 2022).

Lack of Management Support

In SCM network, industry 5.0 requires a determined leadership style, clear strategic vision, participation of top management as well as the influence of internal organization partners, such as interdisciplinary offices and representatives from all progressive levels of the organization, cross-functional collaboration,

new skills development and training (Nimawat & Gidwani, 2021) To bring about change in an industry, both employees and top management can help to develop awareness and sufficient knowledge about the importance of implementing the system. It requires a commitment to impart Industry 5.0 relevant training to employees, including awareness of Industry 5.0, and conducting food loss prevention and waste prevention programs before food items reach consumers etc(Sagi & Gokarn, 2022).

Lack of Technological Skill

Organizations can secure a long-term and reliable workforce by training and increasing the skills of local employees (Aday & Aday, 2020). The workforce often lacks the relevant technical skills and standards which are needed in the standards for the implementation of industry 5.0 (Kamble et al., 2018). When organizations apply industry 5.0 technologies and approaches without having the right technological skills, it may hinder the ability to utilise technology efficiently. In agri-food industry, although farms have already adopted IoT, Blockchains, and AI solutions and implemented different farming platforms, there is still a lack of knowledge and skills regarding how quickly the Agri-Tech field is changing and how to be more efficient, productive, and sustainable (Spanaki et al., 2021). Thus manufacturing firms must obtain the necessary resources, skills, and support to the journey to Industry 5.0 . Manufacturing companies are more likely to embrace industry 5.0 if they possess both tangible resources, such as qualified human resources, machinery, and equipment, and intangible resources, such as skills and capabilities (Hassoun et al., 2022). According to the European Commission report, it aspires to equip at least 54% of people with basic digital skills and to boost the number of ICT, only 4% of people are ICT graduates, and only 20% of organisations provide ICT training to their workers (European Commission, 2022).

Challenges In Adopting Industry 5.0

The adoption of emerging technologies is believed to improve the performance of an organization in terms of cost, productivity, quality, flexibility, and employee satisfaction (Kamble et al., 2020). The Industrial Revolution 5.0 concept, however, remains a vision for the future because it involves a wide variety of issues and faces a wide range of challenges and difficulties, including scientific, technological, economic, social, and political challenges (Zhou et al., 2015; Mohamed, 2018). They are challenges related to unclear economic benefits, lack of standard regulations & laws, low maturity levels of technologies, too slow technological adoption, high investment, value-chain integration, security risks, and resistance to change etc (Xu et al., 2018, Geissbauer et al., 2014). The next section explores the main subthemes related to challenges in Implementing Industry 5.0

The Challenge Of High Implementation Cost

Industry 5.0 and the integration of sustainability and digital architecture to meet business requirements requires substantial initial investment both in terms of budget, cost and time (Sony, 2020), Furthermore, supporting innovative investments and empowering employees through tax planning is an imperative part of business planning. Capital investment is not just limited to the hi-tech implementation in the organization, but also involves employee training, hardware and software, initial installation, digital infrastructure, and R&D skills. It is predicted that investing in industry 4.0 applications will improve profitability and return on investment in the agri-food sector in the future (Hossein Ronaghi, 2020). Geissbauer et al.,

(2014) have estimated that the share of investments in Industry 5.0 solutions at various stages of SCM (Supply chain, procurement, planning, product development, production process, distribution and services etc) will account for more than 50% of planned capital investments for the next five years.

The Challenge Of Lack of Infrastructure

To integrate automation into existing manufacturing processes, industrial managers and decision-makers must allocate significant resources to developing ICT infrastructure due to its significant weight in optimal standards (Moktadir et al., 2018). It is not feasible to accommodate Industry 5.0 in a deficient infrastructure due to a lack of investment or inefficient resource management. To ensure near-real-time data availability, technological infrastructure must be modernized and provide fast, secure, and reliable services (Rüßmann et al., 2015). As soon as the technological infrastructure challenge is overcome, other challenges can be addressed and eliminated easily. Industry 5.0 requires an ICT infrastructure capable of sharing data at a significantly greater volume and higher quality than existing networks thus needing high speed and reliable internet (Sayem et al., 2022). The lackings of ICT infrastructure and unclear contractual arrangements concerning liability, privacy, and the consequences of data loss can lead to the challenge of implementing Industry **5.0** . If ICT infrastructure is lacking thenin will become difficult to undertake horizontal integration, vertical integration, and end-to-end integration for Industry 5.0. (Xu et al., 2018). Therefore, the lack of technological infrastructure is the most crucial challenge that needs to be addressed to implement industry 5.0. The Gartner 2022 survey estimated that 70% of organizations will become automated for flexible and efficient delivery of services by 2025, up from 20% in 2021 (Rimol, 2022).

The Challenge of Data Quality & Security

Old legacy ICT systems will crumble to handle high-quality, more complex and and secure communication). Data security issues, hacker threats etc could be strong potential challenges in IoT implementation concerning security (Raj et al., 2020). Also to improve supply chain integration, organizations need to collaborate with other businesses and share information. This brings in various privacy, data protection and Cyber security risks from third-party software and services and the sharing of information between them (Geissbauer et al., 2014). The quality of data is categorized into four aspects: consistency, completeness, accuracy, and redundancy (Geissbauer et al., 2014). In the age of fully realized big data, the firms are interconnected, and the process will generate large amounts of, heterogenous, complex data leading to problems related to data quality, consistency, and data accuracy etc (Raj et al., 2020).

The Challenge Of Change Resistance

Middle management and employee resistance can act as barriers to organizational change to implement Industry 5.0. Considering the speed at which technology is advancing, employees are not able to meet the rapidly changing demands of their jobs (Felsberger et al., 2020). The resistance to adopting Industry 5.0 technologies can be die to resistance to change incited due to the lack of competencies in employees. The employee's fear of change highlights the need of preparing the mindset of employees to understand digital transformation for Industry 5.0 and to have positive job prospects so that they can up-skill for

different jobs (Khin & Kee, 2022). Training activities and psychological support are necessary to address the change management issues associated with each technology.

Role of Stakeholders

The development of stakeholders is crucial to the implementation of Industry 5.0, as it facilitates the efficient coordination between stakeholders and helps manage internal operations (Parhi et al., 2022),. The stakeholders are the persons or groups with legitimate direct or indirect interests in the business. Stakeholders can be categorized in internal and external aspects. In Agri-food 5.0 several agricultural stakeholders participate in agricultural production, including non-governmental organizations (NGOs), governments, statistical institutes, international organizations, and competitors of agricultural companies (Spanaki et al., 2021). The next section discusses the role of the stakeholders and their significance to manage the industry 5.0 implications in organizations.

Farmers as Stakeholder

Agri-food is primarily controlled by farmers who are the owners of agricultural activity, perform various operations, and collect data. However, a study by Spanaki et al., (2021) found that farmers sometimes require assistance from third parties for data collection. As the agri-food sector involves different educational background people, farmers need to understand the system properly and maintain the partnership with distributors, and manufacturers to achieve high awareness and flexibility. Farmers mostly face challenges due to price fluctuations, production inefficiency, food waste, food safety, etc. (Spanaki et al., 2021). However, the use of technology and data appropriately can help farmers to manage their business operations.

Government as Stakeholder

The implementation of Industry 5.0's is heavily dependent on financial factors including infrastructure investment, supplier improvement initiatives, and stakeholder involvement. In agri-food, governments are responsible for controlling supply chain processes to avoid complex problems, minimize dominant stakeholders, and ensure fair market outcomes. The availability of financial resources (internal or external) is one of the prerequisites for accelerating the digitalization and digital transformation of businesses in Industry 5o. Generally, the government is perceived as a potential source of funds, while every other aspect is expected to receive minimal support (Szabo et al., 2020). Consequently, companies often seek Government grants and subsidies to finance digital transformation investments, due to a lack of internal resources (Szabo et al., 2020).

Supplier as Stakeholder

As suppliers are vital stakeholders in implementing industry 5.0 applications, it has been found that strong commitment among the stakeholders involved can be realized in the form of collaboration. A collaborative approach is essential for sustaining long-term partnerships and spreading benefits throughout the strategic, tactical, and operational levels of the supply chain system (Dania et al., 2016). The role of suppliers in collaboration is to share information about resources and capabilities based on different

factors. The obstacles to implementing collaborative systems in the supply chain include inadequate assessment systems, limited information systems, organizational culture, and reluctance to change. As the supply chain system for agri-food becomes increasingly globalized, collaboration is essential to gain consumer trust, minimize costs, and maximize profits (Dania et al., 2016).

Technology and Service Provider as Stakeholder

A technology provider aims to help businesses integrate digital technologies into their daily operations and improve organizational performance. On the other hand, service providers strive to improve the organizations' services and enhance the effectiveness of technology in business activities. Integrating processes, data, and devices across the value chain can improve end-to-end planning accuracy and streamline operations. Morakanyane et al., (2017) argue that the transformation process is not driven solely by technological advancements, but also by stakeholders at the firm level, such as staff, technology, and service providers for digital transformation. Infrastructure providers and technology providers are the primary stakeholders who facilitate access to these digital technologies (Holienka et al., 2021). The technology or service providers offer a wide range of services and solutions, including marketing activities, data collection, storage, and analysis as part of management and decision-making using appropriate technology under Industry 5.0. Agricultural equipment sellers and manufacturers are facing a broadening business and competition ecosystem as their products become increasingly connected (Porter & Heppelmann, 2017).

In summary, The findings section has identified and discusses the key themes such as influencing factors, challenges, the role of stakeholders, to manage the impact of industry 5 .0 technologies on supply chain performance within the agri-food sector.

DISCUSSION

This section analyses the main themes discussed in the previous section and then evaluates the themes by applying the SCOR model

Factors Related To The Implementation Of Industry 5.0

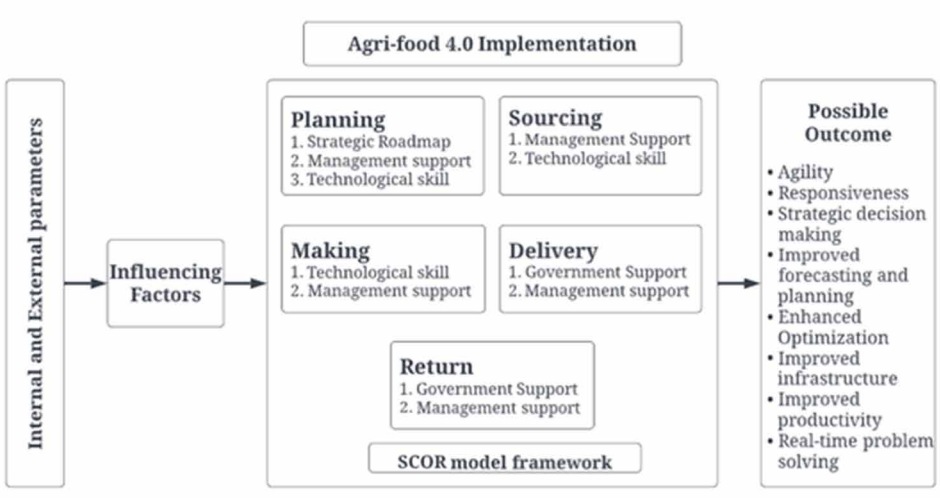
The main influencing factors, related to Industry 5.0 found are; a strategic roadmap and the need of technical skills within the agri-food industry. As findings indicated, the agri-food industry lacks strategic planning. Another factor has been the farmers' ability to modernize their production practices to implement Industry 5.0 strategically. Organizations need to focus on investing in training to adopt industry 5.0 and utilize the technology at its potential. As agri-food sector involves different factors such as seasonality, variability, perishability, traceability, and small-scale production, supply chain managers in the agricultural sector must develop a thorough understanding of the skills and information needed to meet emerging challenges Furthermore, the government can facilitate the funding of the agri-food industry, as well industry-specific research and education, marketing, and infrastructure requirements to remain competitive and employ innovative practices (Zhao et al., 2022). Also, the management should ensure that all employees are familiar with food safety regulations and procedures and can comply with them. Therefore, to overcome the issues concerning food safety, quality, employee training, or strategic

ideas to facilitate industry 5.0, bottom-up and top-down approaches are needed. Figure 1, represents the conceptual framework for influencing factors and is categorized based on the SCOR model, and possible outcomes to help organizations achieve their goals by addressing these factors.

Challenges In Implementing Industry 5.0

Despite many advantages that industry 5.0, the study has identified; uncertainty regarding the ROI and the cost-benefit of industry 5.0 as the main challenge, Yadav et al. (2022) noted that to ensure stakeholder affordability, agri-food industries need to invest less to develop digital technologies. Thus, from a planning perspective, organizations should consider both the return on investment and the technology

Figure 1. Conceptual framework for influencing factors based on SCOR model (Author, 2022)

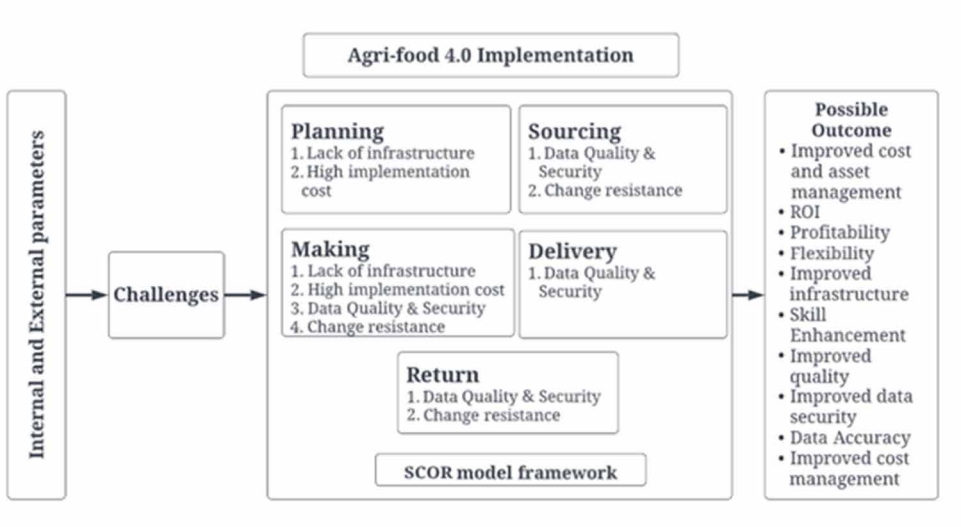


potential for production when making significant investments. Secondly, the organizations will have to incur capital expenditure for developing the industry 5 .0 infrastructure which includes the development of cyber-physical systems, the IoT, cloud computing, and data analytics. A high-speed internet connection is also essential for businesses that rely on cloud-based applications and services. In agriculture, IoT is used largely to enhance productivity and intelligence through an integrated information processing and applications infrastructure (Lu et al., 2015). In addition, it has been observed that food safety concerns and food wastage occur at each stage of supply chain from sourcing to returning which highlights the importance of infrastructure to ensure a safe and reliable food supply (Yadav et al., 2022). Thirdly, farmers might experience great financial loss and emotional distress if sensitive farm information, such as crop yields, cultivation methods, and livestock health conditions, were disclosed to third parties. Thus, implementing blockchain and IoT can assist in preventing unauthorised access to data. Lastly, farmers have faced resistance and challenges in implementing smart farming, particularly concerning advanced technology and data sharing concerns (Spanaki et al., 2021). Figure 2, represents the conceptual framework for challenges and their classification based on the SCOR model and possible outcomes upon overcoming identified challenges.

ROLE OF STAKEHOLDER

Stakeholders play a vital role in implementing industry 5.0 applications in agri-food by providing financial support as well as collaborative support. The agri-food industry involves stakeholders such as farmers, intermediaries, suppliers, consumers, etc. The farmers are primary key stakeholders in the food supply chain who often lack business skills, aspirations, and a system thinking approach, so they focus largely

Figure 2. Conceptual framework for challenges based on SCOR model (Author, 2022)

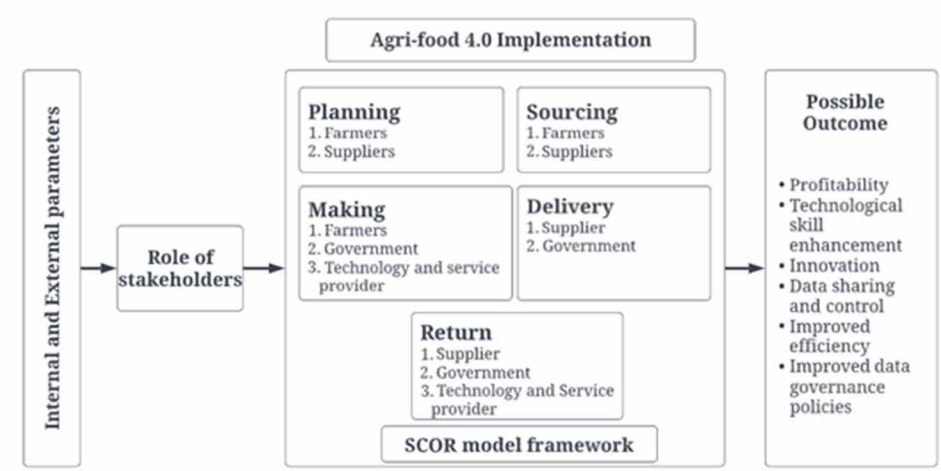


on their own operations rather than collaborating through integrated systems.. Maintaining sustainability within the agri-food supply chain requires appropriate practices from the organization's both upstream and downstream actors. Agricultural information sharing is essential since this industry is extreme in terms of time-criticality, risk, control, security, and requirement for supply chain integration (Spanaki et al., 2021). A central characteristic of Agriculture 5.0 is the ability of suppliers to share information to manage weather variations, water shortages, product perishability and price volatility. Financial institutions such as bank and insurance can provide farmers with a variety of beneficial instruments, from insurance such as crop, livestock, yield, and revenue to credit based on short-term and long-term (Bertolozzi-Caredio et al., 2021). Thus, findings indicate that stakeholders can allow more efficient and cost-effective access to knowledge and technology. Figure 3, represents the conceptual framework for identifying the role of stakeholders and their classification based on the SCOR model and possible outcomes that organizations can achieve with the help of stakeholders.

RECOMMENDATION

Firstly, findings have revealed a few recommendations such as government should create a favourable regulatory environment to encourage innovation in the agri-food sector and ensure that the technology

Figure 3. Conceptual framework for the role of stakeholders based on the SCOR model (Author, 2022)



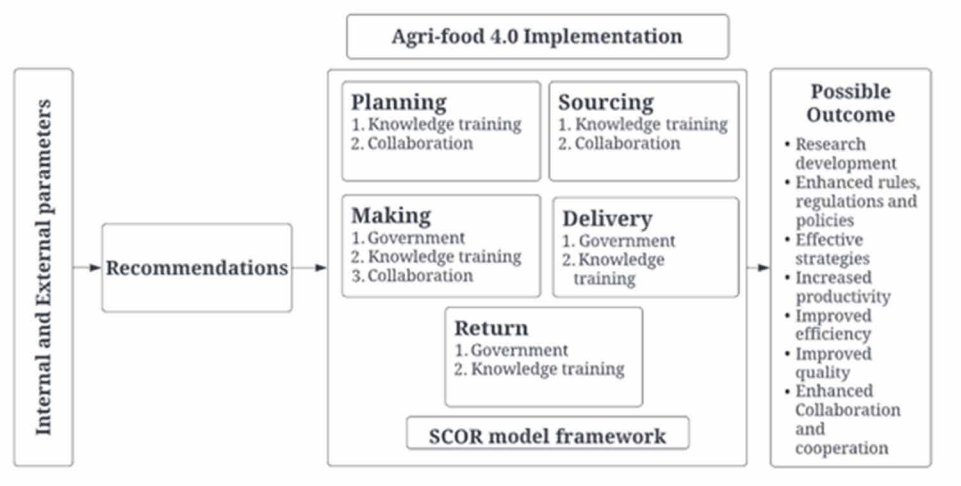
is used ethically and safely. It has been observed that the lack of infrastructure in rural areas is the main obstacle to increasing productivity. Therefore, the government should address the issue of high-speed internet in the agri-food sector and set regulations, rules and policies at related to the implementation of Industry 5.0 . also, collaboration among industry, government, suppliers and academia leads to more research as well as the development of relevant curricula and building effective strategies for the implementation of industry 5.0. Also, the organizations should ensure that all data is encrypted, that appropriate access controls are in place, and that any collaboration with other organizations is done securely. Figure 4, represents the conceptual framework for identifying recommendations from the literature and their classification based on the SCOR model.

OVERALL RECOMMENDATION

Short-term Recommendations

The agriculture industry faces various educational challenges as it involves a different types of educational backgrounds farmers or employees. As underdeveloped countries are facing problems to implement industry 5.0 effectively in the agri-food supply chain due to the paucity of technical knowledge, 'technological self-efficacy' is considered the most influential factor in industry 5.0 adoption. Therefore, it is recommended that there is a constant need to develop skills and knowledge among the local farmers and keep them up to date. The research findings indicate that knowledge training carries several risks, such as high investment, lack of awareness concerning technical developments and a fear of change. To avoid risks associated with the above recommendation, businesses should launch education programs in collaboration with suppliers, academics, and third-party companies, engage in business-to-business (B2B) networks, or the government's recognition of Industry 5.0 best practices.

Figure 4. Conceptual framework for recommendations based on the SCOR model (Author, 2022)



Medium-Term Recommendations

Several authors have already stressed the importance of system integration and interoperability in the reviewed literature. Lack of interoperability reduces the potential for efficiency when using software from multiple providers, as well as making it difficult to access the full range of data and insights that could be used to improve farming practices and make decisions. It also creates a barrier to adopting new technologies, as farmers may be discouraged from investing in solutions if they cannot easily integrate with existing software and systems. Therefore, it is recommended that, organizations must have interoperability in their systems to enhance the supply chain with greater agility, profitability, and resilience.

The research findings indicate that interoperability and infrastructure pose a significant risk of data authorization, identification, updating, and sharing. To avoid the such risk associated with the given recommendation, organizations should work closely with security experts to ensure that all data is collected, stored, and accessed securely. Additionally, organizations must also ensure that they comply with the law in terms of data privacy and security.

Long Term Recommendations

In agri-food industry, it is recommended that organizations must have clear and precise strategic plans for implementing industry 5.0 to ensure alignment with the technical, organizational, and operational characteristics of organization. To adopt industry 5.0 within agri-food sector, a strategic plan needs to be focused on not only the technology perspective, but also the social, cultural, and ecological perspective. Additionally, initiatives taken by the government, stakeholders, and organization itself should appear in long-term strategies.

The research findings indicate that disagreement among stakeholders may pose a significant risk. To avoid the risk associated with the given recommendations, it is necessary to build a strategy with the consensus of all the parties involved. This strategy should involve a comprehensive analysis of the

risks and rewards associated with the suggested course of action and involve all stakeholders in the decision-making process.

CONCLUSION

Finding from SLR has identified four key factors that influence the impact of industry 5.0 on agri-food supply chain operations. The identified factors are lack of strategic roadmap, lack of government support, lack of management support, and technological skill. To implement the strategic roadmap, and provide pieces of training, the government and/or stakeholders can provide financial assistance as well as develop appropriate learning regulations and training programs. Furthermore, findings have indicated the four challenges in managing the impact of industry 5.0 on agri-food supply chain operations; such as high implementation cost, lack of infrastructure, data quality and security, and change resistance. As the majority of farmers in agri-food industry are facing difficulty to cope up with the modern implementation in the farm, change resistance and high investment cost due to the lack of knowledge regarding the ROI and the cost-benefit are identified as the most obvious challenge. The significant primary stakeholders identified are farmers, and the government and secondary stakeholders are suppliers, and technology and solution providers. It is acknowledged that the government plays a significant role among the sector's stakeholders in understanding the needs of the field and implementing appropriate regulations for farmers. It has been found that, the implementation of Industry 5.0 will also be aided by stakeholders' participation in bringing cutting-edge, cost-effective technology to the agri-food supply chains and in providing services to fix defects and maintain data. Finally, ta range of recommendations includes more government support and involving stakeholders to achieve the organizational goal. As a majority of the farmers are not financially capable and or technologically skilled, hence government supports the organization financially, developing initiatives to benefit the farmers, providing educational programmes, and formulating supportive policies.

RESEARCH LIMITATION AND FURTHER SCOPE

The most important limitation lies in the fact that the scarcity of peer-reviewed articles, as the research was conducted through a systematic literature review using a secondary research-based methodology. In addition, this study is limited by the lack of a comprehensive analytical literature review available on industry 4.0 or Industry 5.0 further research could also be conducted by utilizing the primary research methodologies.

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KEY TERMS AND DEFINITIONS

Artificial Intelligence: The term artificial intelligence (AI) refers to cognitive processes and specially to reasoning (Spanaki et al., 2021).

Blockchain: A blockchain is a distributed ledger of digital transactions, which is maintained by multiple computers that is not reliant on third party (Kamilaris et al., 2019).

Industry 5.0: A key component of Industry 5.0 is the convergence of smart manufacturing and products, and the Internet of Things (IoT), and human, social, environmental and sustainability aspects and then using real-time data about the production, machines, and component flow (Chauhan & Singh, 2019).

Internet of Things: In a digital world, the Internet of Things enables things to communicate and interact, providing an accurate representation of the real world to aid development (Dadi et al., 2021).

Operations: "The operations function is the collection of people, technology, and systems within an organization that has primary responsibility for providing the organization's products or services," (Bozarth and Handfield, 2019, p.23)."

SCOR Model: The SCOR model is the most comprehensive standard which involves five processes such as plan make, source, deliver, and return (Bozarth & Handfield, 2019).

Supply Chain Management: Supply chain management facilitates the flow of goods and services to and from organizations and individuals as they need them (Choi et al., 2021).